REVIEW OF EXPLORATION ON

PROSPECTING AUTHORITIES

2212 AND 2225, NORTHERN

TERRITORY

Report No. 157 September 16, 1971

By

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2. Location of Uranium Prospects on Prospecting Authority 2212
INTRODUCTION by G. C. Battey

Over the past three years United Uranium N. L. in Joint Venture with Newmont Proprietary Limited, Electrolytic Zinc Company of Australasia and Peko Mines N. L. have spent $1,200,000 in the investigation of Prospecting Authorities Nos. 2212 and 2225 covering a large area of approximately 3,600 square miles.

On May 7, Noranda commenced formal negotiations with United Uranium under which it was proposed that Noranda, with or without a partner, should be afforded the opportunity to join this Joint Venture by acquiring a part of the interest held by United Uranium.

An agreement in broad principle for the terms of entry was achieved at a meeting with representatives of United Uranium N. L. on June 16.

Arrangements have now been completed whereby Utah Development Company will share the available interest with Noranda on terms under which, provided the interest is acquired in full, they will contribute $1.50 for each $1.00 contributed by Noranda to earn an equal share in the 39% available from United Uranium. A further 1-2/3% is to be acquired in like manner from the interest held by Newmont.

United Uranium have stated that unless negotiations can be concluded in the immediate future, they intend to offer this interest to other parties.
CONCLUSIONS by G.C. Battey

The conclusions reached in a study of the proposed joint venture are set out below:

The area covered by Prospecting Authority 2225 is part of the Alligator River Uranium Province. This conclusion is reinforced as a result of studying the reports on the recent field inspections by A. Thomas and M. Foy.

The work done by the previous parties has not adequately explored the area. The comments made by A. Thomas and M. Foy after studying the available data support this conclusion.

The airborne radiometric surveys completed to date, although inadequate, have defined interesting targets as set out in the report prepared by N. Rodwell after his field inspection.

Noranda has an opportunity to earn an interest in this Joint Venture under favourable terms in which Noranda's contribution is subsidised by Utah.

Our studies to date have established that this is the largest area in the Alligator River Uranium Province currently available.
ERRATA

Page 54 - para. 4, line 2: "duel" should read "dual".
para. 4, line 3: "E. M. transceiver unsuitable" should read "E. M. transceiver, is unsuitable".

Page 55 - sub-para. (a), line 1: "flights 1 to 3 was inclusive" delete "was".

Page 56 - last line: close bracket.

Page 58 - Area 4: after last line add "(These statistics do not include the Melanie Anomaly)".
I recommend Noranda should conclude the agreement whereby it becomes a party to the Joint Venture.
4.1 Geology of Prospecting Authority 2225

4.1.1 Introduction

The uranium deposits of the South Alligator Uranium Field form part of the Katherine - Darwin metallogenic province. This province corresponds roughly with the Pine Creek Geosyncline and occupies an area of some 20,000 square miles. Known uranium deposits occur at Rum Jungle, South Alligator, Jim Jim Creek, Nabarlek and Ranger.

4.1.2 Geology

An Archean basement of altered amygdaloidal basalt, the Stag Creek Volcanics, crops out as discontinuous exposures along the northwest - southeast trend of the South Alligator Fault and as the core of a dome south of the Black Jungle Range.

Unconformably on this basement the Goodparla Group of the Lower Proterozoic (Agicondian System) was deposited (Walpole 1962). These sediments were deposited in the main basin of the Pine Creek Geosyncline and are represented in the South Alligator Valley by the Masson Formation and the Coirwong Greywacke. The Goodparla Group is considered to be a facies assemblage comprising the Mt. Partridge Formation and the Golden Dyke Formation, which is the host rock for the Rum Jungle uranium orebodies. The provenance of these sediments is considered to lie to the north and east and their facies relationships are shown below.

<table>
<thead>
<tr>
<th>West</th>
<th>South Alligator Valley</th>
<th>East</th>
</tr>
</thead>
<tbody>
<tr>
<td>Golden Dyke</td>
<td>Masson Formation</td>
<td>Mt. Partridge</td>
</tr>
<tr>
<td>Formation</td>
<td>(transitional slope</td>
<td>Formation</td>
</tr>
<tr>
<td>(trough</td>
<td>environment)</td>
<td>(marginal shelf</td>
</tr>
<tr>
<td>environment)</td>
<td></td>
<td>environment)</td>
</tr>
</tbody>
</table>
The subsequent sedimentation of the main Pine Creek Geosyncline (Finnis River Group) did not reach the South Alligator area as a subsidiary eastern trough was developed in which the South Alligator Group was deposited disconformably on the Masson formation. Generally the western margin of this eastern subsidiary trough is marked by the exposures of Stag Creek Volcanics cropping out along the north-west regional strike trend. This South Alligator Group, the provenance of which is considered to lie to the east, comprises the Koolpin Formation, the Gerowie Chert and the Fisher Creek Siltstone. The Koolpin Formation, which strongly resembles the Golden Dyke Formation in sediment types, consists of pyritic carbonaceous shales, cherty ferruginous siltstones, chloritic siltstones and brecciated silicified dolomite and acts as the host rock for the bulk of the uranium mineralisation in the South Alligator Valley area. The Zamu Complex of basic sills and dykes completes the Lower Proterozoic sequence.

Granite intrusions dated at ± 1800 million years were synchronous with the Lower to Middle Proterozoic unconformity. These are commonly referred to the Middle Proterozoic in the literature but are now regarded as Lower Proterozoic in age and two are of interest - the Malone Creek Granite which crops out to the west and south-west. Much of the mineralisation of the area has been attributed by various authors to these granites (Sheperd 1962, Walpole 1965).

Unconformably upon the Lower Proterozoic strata the Katherine River Group was deposited. Within the South Alligator area the lower member of the Katherine River Group, the Edith River Volcanics, further sub-divided into the Coronation Member and the Pul Pul Rhyolite, are of major importance. The Coronation Member consists of sandstones, pebble conglomerate and valley fill deposits (locally termed the Scinto Breccia). The remainder of the Middle Proterozoic and Lower Cretaceous sequences are shown on the Stratigraphic Sequence below.

<table>
<thead>
<tr>
<th>Stratigraphic Sequence (South Alligator Valley)</th>
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</thead>
<tbody>
<tr>
<td>Quaternary</td>
</tr>
<tr>
<td>Lower</td>
</tr>
<tr>
<td>Cretaceous</td>
</tr>
</tbody>
</table>
UNCONFORMITY

Middle Proterozoic

Katherine River Group

Kombolgie Formation
(sandstone and conglomerate)

Plum Tree Creek Volcanic Member
(andesite with minor basalt and rhyolite)

Kurrundie Member
(sandstone and conglomerate)

Edith River Volcanics Pul Pul
Rhyolite Coronation Member

UNCONFORMITY

Malone Creek Granite and Cullen Granite

Lower Zamu Complex
(basic sills and dykes)

Proterozoic South Alligator Group
(Fisher Creek Siltstones GerowieChert
Koolpin Formation)

DISCONFORMITY

Goodparla Group
Masson Formation (siltstones and greywacke)
Coirwong Greywacke

UNCONFORMITY

Archean Stag Creek Volcanics
4.1.3 Structure

The Lower Proterozoic sequence has been tightly folded on longitudinal axes trending north-west to south-east. Dips are mostly steep and while minor local overturning can be demonstrated, these folds are generally classified as similar (McManus et al. 1968). To the north of the El Sherana area they plunge to the north-west at 20 degrees while to the south they plunge both north-west and south-east.

The Middle Proterozoic has been gently folded on similar longitudinal axes in open concentric folds. Minor variations in plunge of these folds have led to the conclusion of cross folding on a north-east - south-west set of axes by McManus et al. However, the evidence is highly tenuous and such minor variations can be more easily explained by variations in the Lower Palaeozoic land surface.

Strike faulting is common, along the north-west to south-east trend. These faults are usually high angle reverse faults which commonly become dip faults in the Lower Proterozoic sediments. Later minor north-south and east-west trending faults commonly occur.

4.1.4 Production History

Production of the general Mt. Evelyn area (Walpole, 1962)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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<tbody>
<tr>
<td>Gold</td>
<td>31,141 ozs.</td>
</tr>
<tr>
<td>Tin</td>
<td>272.32 tons (concentrates average 60 - 70% Sn)</td>
</tr>
<tr>
<td>Wolfram</td>
<td>408.043 tons (concentrates average 60 - 70% WO₃) also should include 2,715 tons of ore of unknown grade.</td>
</tr>
<tr>
<td>Lead *</td>
<td>1308.42 tons (ore concentrate at 70% Pb)</td>
</tr>
<tr>
<td>Copper</td>
<td>2950.4 tons (ore parcels averaging 20% Cu).</td>
</tr>
</tbody>
</table>

* These figures were compiled to 1956 and do not include the silver, lead and zinc production from the Evelyn Mine which was 81,500 tons at 5.8 ozs/long ton Ag, 5.8% Pb and 6.1% Zn.
Uranium production from the South Alligator Field (Fisher 1968) is estimated at 143,166 tons of ore yielding 1,852,500 lbs of U₃O₈ i.e. at an average grade of 12.94 lbs/long ton.

Of this uranium, 96% of the production came from six mines - El Sherana, El Sherana West, Saddle Ridge, Coronation Hill, Palette and the Rockhole Mine. The remaining 4% of production came from five small mines and the bulk of it, almost 3%, came from the Scinto V Mine, while Koolpin Creek, Scinto V1, Skull and Sleisbeck contributed small parcels each containing about 6,000 lbs of U₃O₈. Some gold was also recovered in the extraction of the uranium.

Historically following the discovery of uranium at Rum Jungle in 1949 and the proving of an orebody in 1951 the Bureau of Mineral Resources discovered the Coronation Hill mineralisation in 1953. United Uranium N.L. and other parties discovered El Sherana, the Scinto deposits and Sleisbeck mineralisation in 1954 and mining commenced in 1956. Production from the field continued until 1964 and ceased due to the fulfilment of all contracts.

4.2 Description of Uranium Deposits

4.2.1 Major Deposits

In this report major deposits have been classified as those which produced more than 150,000 lbs of U₃O₈.

4.2.1.1 El Sherana and El Sherana West

Due to the close proximity of these orebodies they will be described together.

Production

<table>
<thead>
<tr>
<th></th>
<th>Tons</th>
<th>Grade U₃O₈ lbs/long ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>El Sherana</td>
<td>38,500</td>
<td>12.42</td>
</tr>
<tr>
<td>El Sherana West</td>
<td>21,300</td>
<td>18.35</td>
</tr>
</tbody>
</table>

Reserves

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>El Sherana</td>
<td>2,000</td>
<td>4.0</td>
</tr>
<tr>
<td>El Sherana West</td>
<td>8,500</td>
<td>13.85</td>
</tr>
</tbody>
</table>
Lbs $\text{U}_3\text{O}_8$

<table>
<thead>
<tr>
<th>Produced</th>
<th>Reserves</th>
</tr>
</thead>
<tbody>
<tr>
<td>El Sherana</td>
<td>477,500</td>
</tr>
<tr>
<td>El Sherana West</td>
<td>391,000</td>
</tr>
</tbody>
</table>

The source of these figures are calculations carried out by Mr. Fisher, ex manager of United Uranium N.L. While these are the reserve figures shown it is considered doubtful if re-equipping to extract this quantity of ore would be profitable. In the case of El Sherana West the underground openings could not be easily recommissioned and, as this ore lies below the partially collapsed workings, a new shaft and development would be required before it could be extracted. In addition as it would be necessary to leave a considerable floor pillar beneath the existing workings it is estimated that only about 60% of this material could be extracted.

**Geology** (Wilding and Murphy 1969, Taylor 1968).

The mineralised zone strikes at 308 degrees magnetic and extends with a break between El Sherana and El Sherana West for about 1,300 feet. Extraction from El Sherana was by open pit while at El Sherana West two orebodies were worked by open pit and underground stoping.

All the mine workings, with the exception of the overburden at the El Sherana open cut, were in rocks of the Koolpin Formation of Lower Proterozoic age. These rocks are comprised of interbedded cherty ferruginous siltstones, carbonaceous shale and siltstones and pale coloured shales with nodual chert. There appears to be some bleaching particularly of the carbonaceous siltstones forming a halo some distance away from the orebody. This would appear to be a chemical rather than a temperature effect.
Other Lower Proterozoic units mapped in the mine area are the Fisher Creek Siltstones which crop out to the north-east of the workings and are represented by micaceous siltstones and massive sandy siltstones. A coarse quartz sandstone which crops out to the south-west and is attributed to the Coirwong Greywacke Member.

The Middle Proterozoic is represented by the Coronation Member, consisting of quartz sandstone, pebble conglomerate and micaceous siltstone. This is overlain by a cobble conglomerate with much volcanic detritus which is in turn overlain by the Pul Pul Rhyolite, ignimbrite and quartz feldspar porphyry.

High angle reverse faults striking in a zone a little oblique to the regional north-west trend of the Lower Proterozoic have, by their complex divergence and convergence cut those rocks into blocks.

The unconformity between the Lower and Middle Proterozoic was preserved above the upthrown block of the Koolpin Formation from which the bulk of the ore was mined and can be traced at a lower level (on the downthrown side of the fault) in the north-eastern wall. A small amount of ore was extracted from the overlying Coronation Sandstone and some very low grade uranium tends to follow the unconformity as a flat lying tabular body in the sandstones to the north-west of the open cut and has been evaluated as the El Sherana North West Anomaly (Wyntje 1970). The orebody had a total depth of 140 feet from crest to keel.

At El Sherana West the unconformity has been removed by erosion but is believed to have only been at the most, a few tens of feet above the present surface. The ore was mined from narrow stopes on two lodes. These were located on margins of a block of cherty ferruginous siltstones within a carbonaceous shale sequence. The north-east contact was designated as No. 1 and the north-west as No. 2 contact. The deposition was within the cherty ferruginous siltstones against or close to the carbonaceous shale contacts which are believed to be faults. These orebodies extend over a total vertical depth of 300 feet.
Mineralisation

Threadgold, 1960 identified the ore as pitchblende of colloform habit containing traces of niccolite gersdorffite, two cobalt-nickel arsenides (possibly cobaltian remmelsbergit and safflorite), a nickel selenide, galena, clausthalite, chalcopryrite, pyrite, marcasite and native gold. There are a host of secondary uranium minerals also identified which will not be quoted here.

Detailed geochemical examinations by the C. S. I. R. O indicate that the distribution of uranium in the El Sherana open cut at the carbonaceous shale-siltstone contact favours a supergene origin for the ore.

4.2.1.2 Rockhole Mine

Exploitation of this mine was by South Alligator Uranium N. L. and the property was subsequently acquired by United Uranium.

Production

Production was 13,200 tons at 25.17 lbs $U_3O_8$ per long ton producing 322,500 lbs $U_3O_8$.

Reserves as calculated by Fisher are 1,500 tons 11.04 lbs $U_3O_8$ containing 17,000 lbs $U_3O_8$.

A later calculation after the driving of a lower adit by Wilding, 1969 quotes the reserves as 900 tons at 2.2 lbs $U_3O_8$ containing 2,000 lbs $U_3O_8$.

Much of this discrepancy is that Fisher's calculation are based on the total amount of ore remaining in the old workings.

The later calculation is based on the new adit at the 820 level. Extraction was from narrow underground stope.
Geology

The zone of mineralisation is some 2,300 feet long and strikes at 300 degrees magnetic. Over the strike length from Sterrit’s Prospect to the Rockhole 820 adit the ore has a vertical range of 400 feet in reduced level but is limited to 180 feet on any individual section.

At least two high angle reverse faults cut the Proterozoic strata down faulting the north-eastern block and bringing the Coronation Sandstone and Pul Pul Rhyolite into contact with the Lower Proterozoic Koolpin Formation. One of these faults occurs in O’Dwyer’s Mine and the other in the Rockhole Mine proper. There appears to be an en echelon arrangement of faults. These faults appear to be strike and dip faults within the Lower Proterozoic and to preferentially follow carbonaceous shale horizons. Most of the ore is located on the contact of the cherty ferruginous siltstone and the carbonaceous shale of the Koolpin Formation the hanging wall of the faults. On the north-eastern fault block the Middle Proterozoic Kombolgie Formation is encountered. Minor quantities of ore were located in fractures mostly flat lying in the Coronation Sandstone to the footwall of the fault. Generally the volcanic rocks do not appear to be favoured as hosts. Small quantities of ore have been extracted from above the unconformity between the Middle and Upper Proterozoic and from the unconformity itself. The fault plane in the Rockhole Mine is warped which is interpreted by McManus et alia, 1968, as cross folding and an extremely complicated and unnecessary series of faulting is postulated to explain the observed faulting relationships. All of the observed effects can be simply explained by major reverse faulting with second order fractures and differential movement and adjustment between the competent sandstone and less competent argillites.

Mineralisation

Threadgold identified colloform pitchblende, clausthalite, eskebornite, pyrite, marcasite and chalcopyrite in the primary ore. In a recent study the C.S.I.R.O, have completed a detailed rock
geochemistry study of the 820 level adit at the Rockhole Mine and conclude that as the fault plane is approached uranium, boron, vanadium, nickel and sodium increase markedly and independently of the distribution of other elements. This is compatible with supergene deposition of the uranium.

4.2.1.3 Palette

Production

4,800 tons of ore containing 55,00 lbs $U_3O_8$ per long ton yielding 262,500 lbs of $U_3O_8$. This was extracted from small stopes and a small open cut of very high grade.

Geology

The orebody or more correctly several shoots of high grade mineralisation, occur near the intersection of two reverse faults, one trending 300 degrees and the other 360 degrees magnetic. The total vertical extent of the orebody is 120 feet. Ore deposition has taken place along the contacts of Middle Proterozoic Coronation Sandstone and bleached carbonaceous siltstones of the Koolpin Formation of Lower Proterozoic age. Part of this ore deposition is on the fault contacts and part on the unconformity.

The Middle Proterozoic sequence in the area consist of Scinto Breccia, Coronation Sandstone and volcanic referred to the Kombolgie Formation.

Mineralisation

Threadgold describes colloform pitchblende, pyrite, marcasite and native gold from the Palette area. From the abundance of phosphuranylite (identified in the weathered zone) which does not occur in any quantity elsewhere he concludes that the ore was rich in phosphorous. Sheperd, 1962, also identifies coloradoite and clausthalite.
Remarks

It has been suggested that the Palette orebody is part of a larger orebody upfaulted from beneath the Scinto Plateau. This is possible and may be worth one or two deep drill holes to investigate the possibility. Detailed analysis of all related geological data would be required to obtain optimum siting of such holes. It is considered that the present proposal of U.U.N.L. to drive a 2,500 foot adit is too high a risk of exploration funds in respect to the chances of a possible orebody.

4.2.1.4 Saddle Ridge

Production

A total of 30,000 tons at 5.51 lbs per long ton yielding 164,500 lbs U₃O₈. The ore was extracted by open cut only.

Geology

Lower Proterozoic shales of the Koolpin Formation have been overthrust from the south by an east-west trending reverse fault bringing them into contact with volcanic agglomerate of the Kombolgie Formation of Middle Proterozoic age. Extensive outcrops of Scinto Breccia, extremely hematite rich, occur in the area below the volcanics. The ore has mostly been deposited in the shales of the Koolpin Formation and, while the deposit consisted mostly of secondary uranium minerals, carbonaceous shale occurs in the fault and in the Koolpin shales.

Mineralogy

The ore consists of chiefly secondary uranium minerals, torbernite and autunite etc. However, two deep drill holes encountered small quantities of pitchblende 280 feet below the open cut in dolerite of the Zamu Complex (the vertical extent of the open cut orebody was 90 feet).
4.2.1.5 Coronation Hill

Production

25,700 tons at 5.93 lbs $\text{U}_3\text{O}_8$ per long ton for 152,500 lbs $\text{U}_3\text{O}_8$ were mined from a small open cut with some underground development.

Geology (Zimmerman, 1970 and Taylor, 1968)

The mineralisation is controlled by a north-south trending fault dipping steeply to the west and localised between two north-west, south-east trending shear zones. The western side of the fault is composed of rhyolitic agglomerate believed to be part of a volcanic neck associated with the intrusion of the Pul Pul Rhyolite. The fault zone is in effect a megabreccia of the Koolpin Formation and includes carbonaceous shale and rhyolite. To the east of the open cut a north-west trending quartz vein has been prospected for copper. Low values of the order of 0.5% Cu have been obtained. At the surface malachite with a little azurite is present while at depth chalcopyrite predominates. To the north-east of the open cut, an area has been evaluated for gold and interesting values up to 16.5 dwts/long ton were intersected. However, while the area does appear to be too low grade and too small for a mining operation, numerous samples in this programme have not been assayed and additional work would be required.

Mineralisation (Sheperd, 1962)

Pitchblende, native gold, chalcopyrite, barytes and pyrite were identified. The gold values were high and probably assayed better than 5 dwts/long ton. A small amount of ore remains which probably could not be profitably extracted (800 tons at 7.52 lbs $\text{U}_3\text{O}_8$/long ton - (Fisher)).

4.2.2 Minor Deposits

In this report minor deposits have been classified as those which have produced less than 150,000 lbs $\text{U}_3\text{O}_8$. 
4.2.2.1 Scinto V

Production

A total of 5,700 tons at 8.22 U₃O₈ lbs per long ton yielding 47,000 lbs U₃O₈ was mined from a small open cut.

Geology

The deposit is located on a north-west, south-east trending fault in Koolpin Formation. Coirwong Greywacke crops out to the south-west while Scinto Breccia and Pul Pul Rhyolite cap the ridges to the north-east and south-west of the deposit.

Mineralisation

Pitchblende occurs in the cherty ferruginous siltstones adjacent to carbonaceous shales. It is believed that only the bottom part of a larger El Sherana type orebody was preserved. The unconformity and most of the orebody were removed by erosion. The vertical extent of mineralisation was 50 feet.

4.2.2.2 Scinto VI

Production

A total of 1,700 tons at 3.47 lbs per long ton yielding 6,000 lbs U₃O₈ was mined from a small open cut. Reserves are calculated at 1000 tons at 3 lbs per long ton.

Geology (Harrison, 1970)

A north-west trending reverse fault dipping 60 to 65 degrees to the north-west separates a syenite dyke, possibly of the Zamu Complex from compact basic tuffs of the Lower Proterozoic. The orebody has the shape of a flattened pipe dipping south at 65 to 70 degrees.
Mineralisation

Only secondary uranium minerals were recognised. A recent waggon drilling programme has extended the reserves to 12,000 tons at 2.4 lbs $\text{U}_3\text{O}_8$ per long ton.

4.2.2.3 Koolpin Creek

Production

A total of 2,300 tons at 3.02 lbs $\text{U}_3\text{O}_8$ per long ton yielding 7,000 lbs of $\text{U}_3\text{O}_8$ was mined from a small open cut.

Geology

This deposit is located on a north-west - south-east trending fault in the Koolpin Formation.

Mineralisation

Mineralisation consists of primary pitchblende in cherty ferruginous siltstones and bleached shale of the Koolpin Formation. The vertical extent was 50 feet.

4.2.2.4 Skull

Production

A total of 500 tons at 11.1 lbs $\text{U}_3\text{O}_8$ per long ton yielding 5,800 lbs $\text{U}_3\text{O}_8$ was mined from small stopes.

Geology

The geology is similar to Palette. A north-west to south-east trending strike fault intersects a north-south trending strike fault in the vicinity of the Lower to Middle Proterozoic Unconformity.

Mineralisation

Primary pitchblende occurs in cherty ferruginous siltstones and carbonaceous siltstones of the Koolpin Formation and in the Coronation Sandstone.
4.2.2.5 Sleisbeck

Production

A total of 600 tons at 10.0 lbs $U_3O_8$ per long ton for 6000 lbs $U_3O_8$ was mined from a small open cut.

Geology

Little is known of this prospect as most of the initial geology was undertaken by North Australian Uranium Corporation. However the uranium which is thought to be in the form of pitchblende occurs in shales and quartzites of the Masson Formation. An extensive drilling programme was undertaken in the area in which 51 diamond drill holes totalling 7,825 feet and 530 percussion drill holes totalling 25,000 plus feet were drilled with only low values of uranium reported.

Other Areas

Other minor production was also recorded from Teague's Prospect and the Cliff Face Prospect.

4.3 Ore Controls and Origin

4.3.1 Ore Controls

4.3.1.1 Faulting

In the major uranium ore deposits of the South Alligator Valley structural features appear to have played a major role in ore deposition. All of the major deposits are associated with major faults. The only deposit which cannot be related to a major structure is Sleisbeck, although there is some doubt pertaining to the structure at the Scinto V open cut.
4.3.1.2 Lithology

In all the deposits with the exception of Sleisbeck and Scinto VI the mineralization is either in the Koolpin Formation or the Coronation Member of the Edith River Volcanics. The bulk of this mineralization is confined to the Koolpin Formation and even the lithology of the Masson Formation at Sleisbeck resembles that of the Koolpin Formation. Again, within the Koolpin Formation the bulk of this mineralization is deposited in the cherty ferruginous siltstones near their contact with carbonaceous shales. Much of the mineralization deposited in the Coronation Member or in the Edith River Volcanics is near the carbonaceous shale of the Koolpin Formation. It would appear that the carbonaceous shale (producing a reducing environment) was basically responsible for depositing the uranium (which was most probably being transported under oxidizing conditions).

4.3.1.3 The Unconformity

Many of the orebodies appear to be limited to some extent by the unconformity. This may have acted as an ore control in so much as it could have acted as a barrier to solution transfer, i.e. an upward barrier in the case of hydrothermal solutions or a downward barrier in the case of supergene solutions. Another way in which it could have acted as an ore control is in its control of topography as it has probably strongly influenced the topography (and thus the chemical environment of deposition) since Middle Proterozoic time.

4.3.1.4 Cross-faulting

Matheson, 1960, postulates that east-west cross-faulting acted as an ore control. Recent mapping tends to discount this hypothesis and indicates that cross-faulting plays only a minor local role in ore control.
4.3.1.5 Cross-folding

McManus et al., 1968, postulates cross-folding on axes trending northeast-southwest as a major ore control. The evidence supporting the existence of these cross-folds is extremely tenuous and most of it can be more logically explained by known irregularities in the Lower Proterozoic land surface influencing the deposition of the Middle Proterozoic. This hypothesis has not been disproven but is considered unlikely.

4.3.2 Origin

Numerous origins have been proposed for these deposits. Threadgold, 1960, Shepard, 1962, and numerous other authors favour a hydrothermal origin from the Malone Creek Granite. Taylor, 1968, also favours a hydrothermal origin but believed this to be derived from activity associated with the Edith River Volcanics. More recent work, mostly unpublished, would tend to suggest a supergene origin for the deposits.

4.3.2.1 Hydrothermal Origin

Threadgold, from microscopic studies, prepared the following paragenetic sequence based on samples from El Sherana, Palette and Rockhole Mine.

1. Niccolite (NiAs); cobaltian rammelsbergit (NiAs₂) gersdorffite (NiAsS)
2. Pitchblende (main deposition)
3. Pyrite, marcasite, chalcopyrite, galena, clausthalite, nickel selenide, gold, quartz, siderite and hematite.
4. Pitchblende (very minor).
Generally both Sheperd and Threadgold agree that the deposits were formed at low temperatures certainly less than 450 degrees. A major obstacle in postulating the Malone Creek Granite as the source of hydrothermal fluids is that whilst radioactive, it is low in uranium content and most of its radioactivity is due to thorium. Taylor's source of such a solution viz. the Edith Creek Volcanic activity appears valid as these volcanics do contain uranium in appreciable quantities.

4.3.2.2 Sedimentary Origin

Condon and Walpole, 1955, suggest that the uranium was deposited in off reef limestone facies and later reconcentrated in structural traps by organic processes. Attempts to apply this hypothesis to the South Alligator Field are dubious as the only source rocks of the type mentioned are located at a long distance from the uranium occurrences and the uranium would pass through rocks in which it should be deposited long before arriving at any of the points of concentration in the South Alligator. The only valid source in the South Alligator Field is the carbonaceous shale of the Koolpin Formation which is anomalously high in uranium but it is difficult to see how the uranium could be rendered soluble in a reducing environment.

4.3.2.3 Supergene Origin

From geological and petrological examinations of the rocks associated with the uranium deposits it appears that no high temperatures could have been involved. At best these rocks have only been subjected to temperatures in the range of 150 to 200 degrees C. Recent detailed petrological and geochemical investigations by the C.S.I.R.O. (1969 - 1970) indicate the following:
(a) The ores are depleted compared with the country rock in P, Mg, Ni, Zn, B, Cr.

(b) There is a strong concentration of As in the ores.

(c) Cu is enriched in secondary uranium areas but only background in the primary ores.

(d) There is a positive correlation between U and P.

(e) Typical carbonaceous shales are enriched in Mo, Ni, Cr and sometimes in Cu, Pb and La.

(f) The ore bearing solution must have contained U, As, Se, Te, Co, Ni and Au.

(g) The Fisher Creek Siltstones and the Masson Formation have a lower uranium content than the Koolpin Formation.

(h) Uranium shows a strong correlation with Cr, V and Ga in carbonaceous shales.

(i) In a geochemical profile of the 820 level adit (Rockhole Mine) to the fault zone U, B, V, Ni and Na increase markedly near the fault zone. This distribution pattern is independent of the distribution of other elements in the rock.

Ayres and Eadington, (C.S.I.R.O.) 1970, conclude their report with the statement:

"The distribution of uranium at carbonaceous shale-siltstone contacts at the El Sherana Open Cut and the distribution of uranium and associated elements in carbonaceous shales at the Rockhole Mine are compatible with an origin of the uranium by transport in groundwater under (oxidizing) supergene conditions with precipitation occurring in the reducing environment of carbonaceous shales."
The current origin of these solutions is attributed to leaching from the Edith River Volcanics and possible transport via the porous Coronation Sandstone with deposition in a reducing environment of carbonaceous shales. This hypothesis is further supported by the number of minor occurrences of uranium in these formations at times independent of the carbonaceous shales.

4.3.3 Comparison with Other Deposits

A strong comparison between these deposits and the Rum Jungle deposits can be drawn.

1. Both are associated with major fault structures, the South Alligator Fault and the Grant's Reef Fault.

2. Both are deposited close to, but mostly beneath an unconformity.

3. The lithologies are very similar. Both orebodies are deposited in clastic rocks near their contacts with carbonaceous shales.

4. Both are associated with faults and appear partly controlled by them.

5. Supergene processes are believed to have played an important role in enrichment at Rum Jungle. Current hypotheses for the origin of the South Alligator Uranium Field indicated that supergene processes were responsible for ore deposition.

6. Both deposits are limited in depth.

Many of these features can also be noted at the Jim Jim, Nabarlek and Ranger deposits. Although some of the features may be obscured by the higher grade of metamorphism associated with these deposits.

4.4 Geological work completed to date

Originally the field was explored by the Bureau of Mineral Resources (BMR), South Alligator Uranium N.L. (SAU), North Australian Uranium Corporation (NAUC) and United Uranium N.L. (UUNL). Many of the investigations carried out before 1964 are poorly documented or the documentation has been lost. However, when investigations
have been carried out, e.g. drilling, they are indicated as old work and if possible the source is indicated. Mostly those investigated have been assumed to have had negative results. Each major prospect area is marked on the accompanying 1:250,000 scale map. Where results have been achieved they are noted below.

4.4.1 Rockhole Mine Area

Anomaly N.W. of Teague's

A radiometric grid was produced but the results have been lost and the area has been mapped on photo-scale of 300 feet to 1 inch. No further action is believed justified.

Teague's Prospect (Small Production)

Originally explored by S.A.U. via a shaft 70 feet deep which exhibited minor radioactivity below 25 feet and a small open cut which produced 1,700 short tons of ore, of unknown grade. It has been mapped in detail by U.U.N.L. and 3 waggon drill holes totalling 475 feet were put down but only low results ranging from 0.17 to 0.21 $U_3O_8$ lbs per long ton were obtained.

Rockhole Mine (Production)

The old adits (S.A.U.) have been mapped and sampled in detail by U.U.N.L. This mapping and sampling provided the data for Fisher's calculation of ore remaining at 1,500 tons of 11.04 $U_3O_8$ lbs per long ton. U.U.N.L. drove a cross cut adit for about 350 feet and then drove south along the fault 30 feet beneath the old workings for approximately 950 feet. One rise was completed to the level above. Some 1,200 feet of long hole percussion drilling was done from this adit. The results indicated an additional 900 tons of 2.2 $U_3O_8$ lbs per long ton. The surface of this area has been geologically mapped in a reasonable degree of detail.

The Anomaly at 9600N

The area has recently been radiometrically gridded and geologically mapped in detail. Nine waggon drill holes totalling 1,021 feet were put down and two holes showed some values between 0.26 and 0.57 $U_3O_8$ lbs per long ton.
The Anomaly at 9200N

The area has been recently radiometrically gridded and geologically mapped in detail. Eight waggon drill holes totalling 275 feet were put down with negative results.

The Airstrip Anomaly

The area has been recently radiometrically gridded and geologically mapped in detail. Due to the poor results on similar anomalies 9600N and 9200N, no drilling was undertaken.

4.4.2 The El Sherana Area

Stag Creek

Most of the prospecting is old but it is believed old percussion or waggon drilling was carried out with negative results.

South Alligator Fault Anomaly

The area has recently been radiometrically gridded and geologically mapped in detail. Three waggon drill holes totalling 340 feet were sunk giving low results ranging from 0.12 - 0.30 U₃O₈ lbs per long ton and two diamond drill holes totalling 469 feet gave an intersection of 0.43 U₃O₈ lbs per long ton. This mineralisation was located just above the water-table in the Masson Formation.

El Sherana North Anomaly

Recently the area was mapped in detail and seven percussion drill holes totalling 692 feet sunk with fairly negative results.

High Road Anomaly

An old adit 60 feet in length with two percussion drill holes gave negative to marginal results. The area has recently been geologically mapped in detail.

El Sherana (Production)

The old underground openings and surface exposures have recently been geologically mapped in detail.
El Sherana West (Production)

The old underground openings (accessible) and the surface exposures have recently been geologically mapped in detail. Two deep diamond drill holes totalling 1,344 feet were put down to intersect the lodes in depth, with negative results. The ore reserves here must stand as calculated by Fisher from the sampling and drilling from the old workings, i.e. 8,500 tons at 5.43 UO$_3$ lbs per long ton.

4.4.3 The Koolpin Creek Area

Monolith Prospect

Recently a radiometric grid and detailed geological mapping were carried out over the area. Old waggon drilling had been carried out but no results survived and the results were assumed to be negative.

Charrat's Prospect

Only a minor showing. An old self potential survey was carried out over the area with negative results.

Orchid Gully Prospect

Only old geophysical work, (self potential and radiometric) and one old costean, has been completed.

Koolpin Creek (Production small)

The site of an old radiometric anomaly and an open cut

Koolpin East

Old costeaning and waggon drilling have taken place.

Koolpin East Extended

Old costeaning, waggon drilling and self potential survey were carried out.

Scinto V1 (Production small)

Early work by N.A.U.C. costeaning, shaft sinking and diamond drilling, virtually no results are available. Recent work included detailed geological mapping, extensive waggon drilling and one diamond drill hole of 260.5 feet depth. Results in the diamond drill hole were poor 0.05 - 0.60 UO$_3$ lbs per
long ton. The waggon drilling showed better grades and a reserve of 12,000 tons at 2.4 UO₃₈ lbs per long ton was estimated.

4.4.4 Scinto Plateau Group

The entire area has been subjected to intensive exploration in the early history of the field. Unfortunately much of this work has been lost. However, the entire area from Koolpin Creek to Palette has been virtually pattern drilled by waggon drills. One exploration proposal by U. U. N. L. is to drive a 2,500 foot adit under the Middle Proterozoic cover along the unconformity from Palette to Scinto III. This seems extremely expensive exploration.

Scinto 1 Prospect

An old adit now inaccessible, together with old poor quality geological maps exist.

Scinto II Prospect

Only old mapping, a radiometric grid and an old adit (now inaccessible) were completed.

Scinto III Prospect

Only a lease name - no anomalies.

Scinto IV Prospect

Only old mapping and an inaccessible adit were completed.

Scinto V (Production moderate)

Only an old open cut and old mapping are evident.

Scinto V South Prospect

Old waggon drilling and mapping took place. Recording is of poor standard.

Palette (Production)

Only old mapping of good quality is in existence together with the old workings which are now inaccessible.
Christmas Creek Prospect

During 1961 this prospect was costeaned, percussion drilled and mapped on semi detail scale. Recent highly detailed geological mapping and a radiometric grid did not enhance the prospect.

Pul Pul Hill North and Pul Pul Hill South Prospects

Both prospects are only small radiometric anomalies and no current work is programmed.

4.4.5 Coronation Hill Area

Coronation Hill (Production)

Initial work was done by the B.M.R. and consisted of costeaning, surface geological mapping and a radiometric survey. This programme culminated in the drilling of two diamond drill holes both of which missed the orebody. This was followed by U.U.N.L. waggon drilling which located the orebody and development followed. Later drilling based on two self potential anomalies consisted of five percussion drill holes totalling 381 feet; one hole showed 0.08 - 0.23 U₃O₈ lbs per long ton.

The quartz vein was prospected for copper and six diamond drill holes totalling 1,063.5 feet were drilled. The best result assayed 0.49% Cu and 0.09 U₃O₈ lbs per long ton.

Another major percussion drilling programme was to examine low grade gold occurrences. Results up to 16.5 dwts per ton were obtained and the programme was not fully completed. This area may still be an interesting gold prospect.

Coronation Hill South West Prospect

Old costeans were in the area. It has recently been mapped in detail and radiometrically gridded.

Coronation Hill South Prospect

This old anomaly has been located but no further work has been done.
Skull  (Production small)

Only old mapping and development was carried out.

Saddle Ridge  (Production)

Open cut and moderately good geological mapping was carried out. Two drill holes (diamond?) under the open cut intersected minor pitchblende at 280 feet. Drilling was proposed and the open cut de-watered but was later cancelled.

Saddle Ridge North East Prospect

This has recently been geologically mapped and radiometrically gridded in detail. No recommendations for further work have been put forward.

Saddle Ridge East Prospect

The area has been geologically mapped and this mapping is of moderate quality. Five costeans have been put down and 66 wagon drill holes totalling 5,000 feet were sunk. Much of this is old work and the best grades encountered were $48 \text{U}_3\text{O}_8$ lbs per long ton. However, the mineralised body even at 0.5 lbs per long ton cut off appears very patchy.

Saddle Ridge East Extended Prospect

The old prospect could not be located.

Saddle Ridge South Prospect

An old shaft 200 feet deep was sunk, rough geological mapping and 800 feet of waggon drilling was completed. No new work has been carried out on this prospect.

Palms Prospect

Recently this prospect has been radiometrically gridded.

Clear Springs Prospect

This old prospect could not be found.
Coronation Hill South East Prospect

One diamond drill hole was put down to 490 feet with negative results.

4.4.6 Other Prospects

Dinner Creek Prospect

No new work was undertaken. No old results are available.

Flying Fox Prospect

Costeaming only was completed.

Stockpile No. 1 and No. 2 Prospects

Old waggon drilling with poor recording. Both prospects have been recently geologically mapped in detail with negative results.

Butterfly Pool No. 1 and No. 2 Prospects

These prospects have recently been radiometrically gridded using rough geological maps.

Helicopter Anomaly

Recently radiometrically gridded but the prospect is on black soil and was subsequently disregarded.

Faraway Anomaly

Reconnaissance work only has been carried out.

Coirwong Gorge Prospect

Some costeaming is present together with an old radiometric grid.

4.4.7 Sleisbeck Area

Sleisbeck (Production small)

N.A.U.C. drilled a total of 51 diamond drill holes totalling 7,825 feet and some 530 waggon drill holes totalling in excess
of 25,000 plus feet. All of this work yielded negative results, apart from the small parcel of ore shipped from the open cut.

**West Sleisbeck Prospect**

One diamond drill hole of 182 feet was drilled by N.A.U.C. with negative results.

**Upper Katherine Prospect**

One diamond drill hole of 50 feet was drilled by N.A.U.C. with negative results.

Numerous other prospects are listed in this area on which little work has been completed, namely the Turn Off Creek, North Upper Turn Off Creek, Upper Gimbat Prospect and a prospect between Turn Off Creek and Birdie Creek.

**General Geological Mapping**

Much of this South Alligator Field from Teague's Prospect in the north to Coronation Hill in the south has been mapped at enlarged photo scale, i.e. 300 to 400 feet to the inch. This mapping though rough, is generally reliable.

**4.4.8 Other Prospects for Base Metals**

Minor examinations have been conducted at Painted Rock, Little Italy, Malone Creek Granite Copper Show and the Big Sunday S.E. Gossans for Copper; the Zamu Lead Show by U.U.N.L.; Broken Hill Proprietary have also drilled four holes in the northern section of the area at:

1. **Mundogie Hill** - one diamond drill hole 298 feet in length with some interesting gold values in a small vein.

2. **Black Jungle Range** - two diamond drill holes, one 242 feet the other 142 feet. Recovery was poor; less than 50%. Holes were negative.

3. **Black Jungle Springs** - one diamond drill hole for 242 feet with only 26% recovery and negative results.
4.5 Geochemical Exploration

Geochemical methods of exploration have been neglected and or not effectively applied in the evaluation of the South Alligator River area.

Early in the exploration of the area and before the formation of the original Joint Venture experimentation with uranium determinations for stream waters, collected at the beginning of the wet season, was attempted. The method was rejected because of lack of sensitivity of the then available analytical methods, non-reproducibility of results and the strong seasonal dependence of this method on the monsoonal rains. (Sheperd, 1960 and 1961).

Later attempts to apply stream sediment sampling techniques were mostly directed towards locating base metal anomalies in the areas of the Authority to Prospect outside of the known uranium mineralisation, i.e. in the Black Jungle Range area and the Malone's Creek Granite area. In the Black Jungle Range survey, 1880 samples were assayed for lead, copper and zinc, while 360 panned concentrate samples were assayed for gold and tin and another 200 samples were assayed for phosphorus as an indicator for uranium. (Strum, 1967). From these results 45 areas of anomalous base metal content were defined but no indication of uranium was found. It should be pointed out that of the numerous known uranium occurrences, only at the Palette ore body was anomalous phosphorus found so the indicator association can only be regarded as tenuous. No feasibility study appears to have been undertaken in this survey and as a result its conclusions are doubtful.

An attempt was also made at a feasibility study for uranium stream sediments over known mineralisation, however, the results are probably spurious due to contamination. (Wilding, 1969).

Soil geochemistry has been experimented with and a feasibility study completed (Taylor, 1969). In this study the primary rock geochemistry for El Sherana West, Rockhole mine, Coronation Hill and Palette were determined and a brief review of this data is shown below.

lead consistently high 100-5000 ppm.
copper less than 60 ppm (except Rockhole 55-4000 ppm).
nickel less than 60 ppm.
cobalt low.
mercury highest in Rockhole and Palette.
selenium highest in Palette 40-80 ppm, but usually less than 8 ppm.
gold generally 1-12 dwt/ton.

Soil sample lines were then placed in areas where contamination was expected to be minimal at Teague's, Rockhole No. 2 adit, Sherrit's and the Airstrip anomaly. Determinations were made for lead, copper, gold, nickel, cobalt, mercury and uranium on these samples. At Teague's the number 1 line gave highs for uranium, lead, copper and mercury over the known mineralisation and the number 2 line gave highs for all metals except mercury. For the remaining areas the data is highly inconclusive.

Rock chip geochemistry was attempted in the Black Jungle area by A. Vanderplank in 1964 and numerous samples showed anomalies for nickel, zinc, cobalt and copper. Little is known of this survey which was reported on by R. G. Dodson (Report undated and no reference) from Vanderplank's notes at a later date. Since the data recording is poor it may be true that some or all of these anomalies may represent surface enrichment.

From the mineralogy of the ores and the above geochemical work the elements known or likely to be associated in anomalous concentrations with the uranium mineralisation are gold, lead, copper, nickel, cobalt, mercury, selenium and arsenic. The available regional evidence (Walpole and Crohn, 1965) strongly suggest that traces of copper, cobalt, nickel, lead, zinc and uranium can cause geochemical anomalies in the Lower Proterozoic rocks by lateritic processes. Thus any geochemical programme in this area must have a strong geological interpretation and a controlled orientation survey to render it valid. None of the minor geochemical programmes undertaken by United Uranium fulfil these necessary conditions and are thus highly suspect.

4.6 Comments on Programme to Date

4.6.1 The broad geology of the area surrounding the known deposits has been mapped on a reasonable scale of 350 feet to the inch. This work may need revision in part but is generally reliable.

4.6.2 The current detailed mapping on a scale of 40 feet to the inch is of high standard and completely adequate for prospect examination.
4.6.3 The surface radiometric gridding is adequate.

4.6.4 The management of the programme appears to be poor.

(a) Of the fifty-eight mines and prospects which have undergone examination or are noted in this report, thirty-nine were known in 1960. Of the remaining nineteen most of these are only minor and at least five to ten could have been rapidly dismissed. This rate of prospect development appears poor and more effort should have been directed in the search for new prospects.

(b) Until recent months very little attempt has been made to explore outside of known occurrences of uranium.

(c) The driving of 1,400 feet of adit with approximately 40 feet of raising and 1,200 feet of underground percussion drilling as completed at the Rockhole Mines, appears to be an extremely expensive method of searching for a target of 300,000 lbs of $U_3O_8$. It would appear that no appreciation of risk capital to target potential was considered by management.

(d) Little attempt has been made to employ geochemical techniques.

(e) Airborne radiometric surveying was delayed until too late in the programme.

4.7 Current Programme

The current programme is aimed at following up anomalies outlined during airborne radiometric surveys. This work has shown in the area to the north of the known deposits numerous anomalies in the Kombolgie Formation, in laterites developed on Lower Proterozoic rocks and in black soil areas. These anomalies are currently being located on the ground. As this is the programme currently in operation it is not as yet fully documented. The area to the north still has not been completely flown. The Faraway, Butterfly Pool and Helicopter anomalies have been partially investigated as a stage of this programme.
5. GEOLOGY AND EXPLORATION OF PROSPECTING AUTHORITY 2212

by M. F. Foy

5.1 Geology of Prospecting Authority 2212.

The area of P.A. 2212 has been subdivided into three tectonic areas, the longitudinal axes of which trend east-west. From the north these are the McArthur Basin, the Murphy Tectonic Ridge and the South Nicholson Basin. The broad stratigraphy of the area is shown below. For greater detail the notes to accompany the Calvert Hills 1:250,000 geological map should be studied.

5.1.1 Stratigraphy

- Lower Cretaceous
  - UNCONFORMITY
- Lower Cambrian
  - UNCONFORMITY
- South Nicholson Basin
  - Upper Proterozoic
    - South Nicholson Group
      - Constance Sandstone
      - Wallis Siltstone Member
      - Pandanus Siltstone Member
    - UNCONFORMITY
- Lower Proterozoic
  - Fickling Beds
  - UNCONFORMITY
- McArthur Basin
  - Lower Proterozoic
    - Karns Dolomite
    - UNCONFORMITY
    - Tawallah Group
      - Fish River Formation
      - Masterton Formation
      - Gold Creek Volcanic Member
      - Wollogorang Formation
      - Settlement Creek Volcanics
      - Aquarium Formation
On the Murphy Tectonic Ridge the oldest rocks in the area, the Murphy Metamorphics, are exposed. These geosynclinal pelites have been subjected to low grade regional metamorphism producing schists and gneiss and are isoclinally folded about an east-west longitudinal axis. They have been intruded by the Nicholson Granite and contacts between the two are often gradational. Unconformably overlying these are the Cliffdale Volcanics of rhyolite to dacitic composition and including some thin tuffaceous sediments and agglomerates. They have been intruded by the Norris Granite which may represent a late stage differentiate of the Nicholson Granite.

The Tawallah Group, also of Lower Proterozoic age, was deposited unconformably on the above sequence. Only two members of this group crop out within the area - the Westmoreland Conglomerate and the Peter's Creek Volcanics. The Westmoreland Conglomerate consists of sandstone, arkose and conglomerate and thins from a maximum thickness of more than 5000 feet in the McArthur Basin, to less than 500 feet in the South Nicholson Basin. Overlying the Westmoreland Conglomerate are the Peter's Creek Volcanics, an andesine basalt with minor agglomerate and tuff, which shows a similar thinning over the Murphy Tectonic Ridge and in the South Nicholson Basin. A prominent sandstone member, the Carolina Sandstone Member, is enclosed within the Peter's Creek Volcanics. The Fish River Formation (of the Nicholson Basin), feldspatic and quartz sandstone and some basic to intermediate lava, is possibly the equivalent of the
Masterton Formation (of the McArthur Basin). The Tawallah Group is more completely represented and the McDermott Formation, the Sly Creek Sandstone, the Aquarium Formation, the Settlement Creek Volcanics, the Wollogorang Formation, the Gold Creek Volcanics and the Masterton Formation crop out in the northern section.

Unconformably overlying these sediments and volcanics is a carbonate facies, the Fickling Beds (in the Nicholson Basin) and the Kars Dolomite (in the McArthur Basin). In the South Nicholson Basin deposition continued unconformably in the Upper Proterozoic and the South Nicholson Group comprising Pandanus Siltstone, the Wallis Siltstone Member and the Constance Sandstone was deposited.

Deposition of a flat lying sequence of Lower Cambrian age, the Bukalava Sandstone and similar flat lying Lower Cretaceous sediments completed the stratigraphic history of the area.

5.1.2 Structure

Numerous east-west trending strike faults, paralleling the trend of the Murphy Tectonic Ridge have cut the South Nicholson Basin and some of these may have been active during sedimentation. While in the McArthur Basin the dominant fault trend is 125 degrees paralleling the prominent wrench fault named the Calvert Fault.

5.1.3 Mineralisation

Uranium, copper, tin, tungsten, lead, manganese and gold mineralisation occur in the area but there has only been significant production of copper and uranium. Approximately 1000 tons of copper ore assaying between 25% and 52% copper has been produced, mostly from the Redbank Field. Uranium has been produced from two mines, the Eva or Pandanus Creek Mine and the Cobar II Mine, both of which are held by the Joint Venture in P.A. 2212.

Eva            306 long tons at 8.37% \( U_3O_8 \)
Cobar II       71.6 long tons at 10.52% \( U_3O_8 \).
Moderate reserves of between 40,000 and 100,000 tons of ore at grades between 14.5 and 8.0 lbs U₃O₈ per long ton have been estimated to remain at the Eva Mine.

Uranium occurrences are numerous in the area and much of the current exploration has been devoted to finding an orebody similar to the Westmoreland deposit. At Westmoreland the uranium mineralisation is located in near vertical bodies in basic dykes near their contact with the Westmoreland Conglomerate and as flat lying bodies within the Westmoreland Conglomerate. Secondary uranium minerals, mostly carnitite and torbernite in coarse grained feldspathic sandstone and probably of supergene origin are common in the adjacent Westmoreland area in Queensland, e.g. Buck Hill, Contact, Long Pocket and Redtree Prospects.

The uranium occurrences within P.A. 2212 probably show similarity to these areas and are thought to form part of the same province of uranium mineralisation.

Known copper mineralisation within the area of P.A. 2212 appears to be closely associated with the intrusion of the Norris Granite and may not bear any relation to the latter phase of copper mineralisation at Red Bank which is closely associated with the later Gold Creek Volcanic Member. The suspected equivalent rocks in the southern part of the area, the lavas of the Fish River Formation, are not known to carry copper mineralisation. In the north-western section of the area, however, the Golden Creek Volcanics crop out and should be prospected for copper.

5.2 Description of Uranium Deposits

5.2.1 Eva or Pandanus Creek Mine

Production

The production of uranium from this mine was by South Alligator Uranium N.L. and amounted to 306 tons at 8.37% U₃O₈ by selective underground mining to a depth of 83 feet. Ore reserves have been estimated by various authors and are summarised below:
<table>
<thead>
<tr>
<th></th>
<th>tons</th>
<th>Grade lbs U₃O₈/long ton</th>
<th>Content lbs U₃O₈</th>
<th>Cut off grade lbs U₃O₈/long ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>B.H.P.</td>
<td>54,000</td>
<td>12.4</td>
<td>675,000¹</td>
<td>5.6</td>
</tr>
<tr>
<td>U.U.N.L. (Sheperd)</td>
<td>43,000</td>
<td>14.5</td>
<td>620,000²</td>
<td>2.0</td>
</tr>
<tr>
<td>U.U.N.L. (Griffiths)</td>
<td>60,000</td>
<td>11.0</td>
<td>660,000</td>
<td>-</td>
</tr>
<tr>
<td>Newmont (Lindsay)</td>
<td>100,000</td>
<td>8.7</td>
<td>860,000¹</td>
<td>0.9</td>
</tr>
<tr>
<td>U.U.N.L. (Taylor)</td>
<td>95,000</td>
<td>8.0</td>
<td>760,000³</td>
<td>1.0</td>
</tr>
</tbody>
</table>

The above figures have been rounded to the nearest thousand.

1. No allowance was made for ore already mined.

2. Mined sections were excluded from calculation.

3. Allowances were made for 57,000 lbs U₃O₈ sold and 37,500 lbs U₃O₈ presumed lost from the dumps by leaching.

The earlier estimates by Broken Hill Proprietary and United Uranium N. L. are for selected underground mining, while the latter estimates by Newmont and U.U.N.L. are for a projected open cut. While the area is remote and the reserves are small by comparison with other deposits, this could be sufficient to maintain a small mining operation and thus be considered an asset in evaluating this area.

**Geology**

The deposit is located in a small lens of sheared sericite-epidote quartzite, which trends 75 degrees magnetic and dips north at 65 to 75 degrees in the Clifdale Volcanics. Its length is about 180 feet and it is up to 30 feet wide. The orebody appears to bottom close to the contact of intruded Norris Granite, within 10 to 30 feet of the contact. Petrological examination has shown that hydrothermal metamorphism has effected the sediments in part. This and its close spatial relationship to the granite have lead to
the belief that the deposit is of hydrothermal origin.

The orebody is also closely related to the unconformable contact between the Cliffdale Volcanics and the overlying Westmoreland Conglomerate.

Mineralisation

The mineralisation consists of pitchblende with much secondary sklodowskite, boltwoodite and beta-uranophane. Minor amounts of galena, manganese oxide, copper carbonates and erratic gold and silver values have been recorded.

5.2.2 Cobar II Mine

Production

A small mining operation produced 71.6 tons at 10.52% U₃O₈ from a shaft 106 feet deep. Some 2,000 tons of ore estimated to contain 1% U₃O₈ have been inferred below the old stopes.

Geology

The deposit is located in a shear zone up to 10 feet wide, striking a little west of north, in the Peter's Creek Volcanics. The same shear zone has been projected south and intersects near the Old Parr Prospect where it has been assumed that this shear is responsible for the weak uranium mineralisation present.

Mineralisation

Mineralisation consists of pitchblende with abundant specular hematite and some uranium ochres.

5.3 Ore Controls and Origin

5.3.1 Ore Controls

Exploration in the area has failed to locate any large basic
dykes similar to those at the Queensland Mines Westmoreland area. Only one structure similar to this, i.e., a topographical low representing a dyke, intruded along a fault trending north-northeast to south-southwest, has been found in the area. This structure was not associated with anomalous radioactivity, nor was it found to contain any dyke material.

Some minor trachyandesite dykes intruded along north east-southwest trending faults and associated with uranium mineralisation have been found in the north-east Westmoreland area but do not appear to be economically significant.

Radioactive anomalies have been found in:

1. The top bed of the Westmoreland Conglomerate on the dip slope inclined below the Peter's Creek Volcanics.

2. Near the base of the Peter's Creek Volcanics sometimes associated with (1).

3. Along prominent fault zones between the Westmoreland Conglomerate and the Clifdale Volcanics.

The major control of mineralisation within this area appears to be lithological, although there is evidence of a structural control in some anomalies.

5.3.2 Origin

While a hydrothermal origin has been postulated for the Westmoreland and the Eva Mine deposits, this appears at variance with the regional evidence. Uranium mineralisation is widespread and usually associated with the development of much specular hematite, indicating a supergene origin.

I consider that the uranium was leached from volcanics, probably the Peter's Creek Volcanics and possibly the Gold Creek Volcanics, and concentrated near the Peter's Creek Volcanics, Westmoreland Conglomerate boundary. Where the groundwater containing the uranium was able to penetrate into the Westmoreland Conglomerate the
porous sandstones acted as carrier beds and allowed concentration where physio-chemical changes occurred in structural or lithological traps.

5.4 Geological Work Completed to Date

5.4.1 Regional Geological Mapping

Air photographs of the area were produced by QASCO in 1968 at scales of 1:50,000 and 1:10,000. A photogeological map was then prepared by Geophoto Resources during 1969 at a scale of 1:24,000. This map differed little in general geology from the 1:250,000 B.M.R. geological map but contained much finer structural detail. These maps were ground checked and some areas in the vicinity of the Peter's Creek Volcanics, Westmoreland Conglomerate contact were mapped in greater detail at a scale of 1:10,000.

Initial geological reconnaissance during 1968 consisted of locating and examining the airborne radiometric anomalies defined during the B.M.R. survey of the area. Of the 36 anomalies examined, only 4 areas were considered of sufficient merit to warrant more detailed examination. Since this airborne radiometric survey had failed to define as anomalies the Eva Mine, the Cobar II Mine and the El Hassen anomaly, the Joint Venture Partners proceeded with ground radiometric reconnaissance of much of the area considered geologically favourable for uranium occurrences. Thus, several hundred square miles have been examined in this matter by foot and horse traverses.

5.4.2 Eva Mine

This property was first investigated by B.H.P. who surface mapped the area and used extensive costeaning. They drilled 4 diamond drill holes totalling 469 feet and pattern percussion drilled at 20 foot centres with 144 holes totalling 8,774 feet. The property was subsequently sold to and exploited by South Alligator Uranium N.L., by selective underground mining.

United Uranium N.L. has mapped the area in detail, carried out radiometric traversing of the area, carried out extensive geochemical surveys and drilled 3 diamond
drill holes totalling 770 feet to investigate a postulated easterly plunge to the ore body. These holes were numbered DDH 4 to 6 and the results are summarised below:

DDH 4  52 feet at 15.4 lbs U₃O₈/ton.

DDH 5  Significant values ranging from 1.6 to 6.9 lbs. U₃O₈/ton but the overall intersection was extremely patchy.

DDH 6  2.7 lbs U₃O₈/ton over 2 feet was the only significant value.

These holes have not significantly increased the ore reserves which remain at the values previously quoted.

5.4.3  Cobar II and the Old Parr Prospect

This area was originally investigated by North Australia Uranium Corporation by costeansing a shallow shaft with some underground development and 7 percussion drill holes, only one of which intersected mineralisation of 12.5 lbs U₃O₈/ton. It was then developed by a private syndicate and a small tonnage of ore was produced. The Joint Venture has mapped the area in detail and gridded it radiometrically. One diamond drill hole 600 feet in length did not intersect the shear zone but passed directly from Peter's Creek Volcanics into the Westmoreland Conglomerate with negative results. In addition two percussion drill holes totalling 455 feet were drilled and one gave a 17 foot intersection of 1.4 lbs U₃O₈/ton. No additions to the quoted reserves could be made as a result of this programme.

5.4.4  El Hussen Prospect

Mineralisation occurs in a shear zone in bleached Peter's Creek Volcanics approximately 12 feet wide. It was first investigated by N.A.U.C. by radiometric gridding, numerous costeans, a cross cut adit and other development totalling 450 feet and 13 diamond drill holes totalling 1,400 feet. Only two drill holes intersected low grade mineralisation. United Uranium have geologically mapped the area in detail and radiometrically gridded a large area. Patchy radiometric anomalies were formed over a strike length of 7,000 feet. Seventeen percussion
drill holes were drilled totalling 1,475 feet with an additional 38 feet of diamond coring, but only low values varying from 0.2 to 0.6 lbs were found in the sheared volcanics. A diamond drill hole of 436 feet was also drilled with negative results.

5.4.5 Northeast Westmoreland Area

In this area sandstones of the Westmoreland Conglomerate form a prominent strike ridge trending east-west with a north facing dip slope below the Peter's Creek Volcanics dipping at 5½ degrees. There is a prominent northeast-southwest trending fracture which has been interpreted as a fault. The area has been geologically mapped and an area 3,000 feet by 500 feet radiometrically gridded disclosing two anomalous areas, one to the west of the fault 2,400 feet by 350 feet and one to the west 800 feet by 250 feet, of a low order of magnitude. Three costeans were dug and 14 percussion drill holes drilled totalling 1,251 feet. In most of these holes results ranging from 1 to 3 lbs U₃O₈/long ton were found over a thickness of 6 inches to 1½ feet at the contact between the Westmoreland Conglomerate and the Peter's Creek Volcanics. This mineralisation is extensive as it was found in D.D.H. 13 approximately 1,000 feet away from the main drilling area. Some narrow trachyandesite dykes 3 inches to 11 feet in width were found when 6 more holes totalling 966 feet of percussion drilling and 615 feet of diamond coring were put down to investigate the north-east trending fault. These dykes contained an average of 0.37 lbs U₃O₈ per long ton (excluding a high of 3.35 lbs U₃O₈ per long ton) against a background of 0.88 lbs U₃O₈ per long ton in the sandstones.

5.4.6 Fish River Anomalies (Melanie Anomaly)

This area has been geologically mapped, radiometrically gridded and, on the largest of the anomalies, several costeans have been dug. The mineralisation appears to be associated with a black soil swamp (the black colouring is caused by charcoal). These anomalies have been explained by water carrying uranium draining from an aquifer at the base of the Constance Sandstone into the swamp and being deposited by the reducing environment of the free carbon. The anomaly was only associated with the black soil and bedrock gave a count only a little above background.
5.4.7 Milestone Volcanic Vent

An elliptical volcanic neck 300 feet by 150 feet of volcanic agglomerate, partly shattered and silicified, is surrounded by amygdaloidal volcanics of the Peter's Creek Volcanics. The area has been geologically mapped and radiometrically gridded producing low anomalies.

5.4.8 Chapman's Area

An area 5\(\frac{1}{2}\) miles by \(\frac{1}{2}\) mile was geologically mapped at a photo-scale of 800 feet to 1 inch and radiometric reconnaissance carried out. Four radiometric anomalies were found: Red Rock, Fillet Reef, Lost Anomaly and Chapman's. Some additional work was carried out at Fillet Reef where small pits showed weak mineralisation over several hundred feet of strike length. Additional work appears necessary on these anomalies.

5.4.9 Other Uranium Anomalies

Several other radiometric anomalies have been located and radiometrically gridded and geologically mapped. These are the Crippled Horse, Rocky Creek, Hommet's Knob, Jackson's Pit, Jacques Anomaly, Maniw's anomaly and Granite Knob.

5.4.10 Other Mineralisation

5.4.10.1 Crystal Hill

A hill of biotite quartz greisen containing sporadic cassiterite and wolframite was investigated by B. H. P. by costeaming and drilling.

5.4.10.2 Norris's Copper Prospect

Rich oxide copper ores have been mined to a depth of 50 feet from a sheared contact between the Cliffdale Volcanics and the Norris Granite. Below this depth the ore zone narrows and becomes chalcopyrite with a decrease in grade. The mineralisation occurs sporadically over a strike length of 8,000 feet but is very narrow.
5.5 Geochemical Exploration

A geochemical orientation programme was carried out in the environment of the Eva Mine. Six rocks from the Eva Mine were assayed for numerous elements and showed highs for Pb, Cu, Co, Bi, Sn, Mo, Ag, Au and Hg. Core assayed from the three diamond drill holes showed:

(a) Pb was closely associated with the uranium.
(b) Cu was high away from the uranium.
(c) Zn was low.
(d) Bi was low but appeared to be associated with Cu.
(e) Au was closely associated with the uranium.
(f) Co and Ni showed no particular affinity and were generally low.

From this assay data it was concluded that the uranium is associated with Pb, Au, Ag, Hg and Se and that Bi and Cu may form a dispersion halo around the orebody. Test stream sediment samples were taken and it was found that Bi, Hg, Au and Ag could weakly indicate the position of the mineralised zone. A soil sample grid was also placed over the area to the east and south of the mine and the samples assayed for Cu, Pb, Zn and Bi. Very little significance is attached to the broad low copper anomaly defined in this programme.

A geochemical stream sediment programme was also undertaken in the Fickling River Area. Three anomalous areas were defined, one in the east, one in the north-west and one in the south-west of the area. All of these anomalies were defined mostly on the Pb values. More detailed work was undertaken on the north-west anomaly and a hematitic fracture zone gave assays between 0.24 and 0.42 lbs U3O8 per long ton.

The south-west anomaly has been disregarded but in my opinion requires additional work. (Pb values of 600 ppm have been recorded.) These may be caused by small veinlets of galena in the Fickling Beds but additional confirmation is necessary. The eastern anomaly has not been evaluated.

Another geochemical stream sediment programme is planned for the northern section of P.A. 2212, basically to prospect for copper. Disseminations of copper have been reported in the Karns Dolomite of possible syngenetic origin and copper is known from the Red Bank Area associated with the Gold Creek Volcanics which also crop out in the north-western part of P.A. 2212.
5.6 Comments on Programme

1. Regional geological mapping has been adequate and systematically undertaken.

2. Detailed geological mapping has been well carried out and is adequate for prospect evaluation.

3. Radiometric gridding on prospects has been well executed and is adequate for prospect evaluation.

4. Core and sample storing is extremely poor and information which could be vital to future programmes is being lost.

5. An airborne radiometric survey has been left until too late in the Joint Venture programme and this may lead to unnecessary duplication of surface prospecting.

6. The application of geochemical techniques would appear to be inadequate particularly in respect to the types of programmes initiated and the inadequate orientation surveys.

7. There has existed throughout the earlier stages of the programme a tendency to overdrill prospects.
6. COMPARISON BETWEEN URANIUM DEPOSITS OF SOUTH ALLIGATOR WITH RECENTLY DISCOVERED DEPOSITS AT NABARLEK, RANGER AND JIM JIM by A. Thomas

6.1 Proximity to Unconformity

None of the uranium deposits in the Northern Territory appear to lie far below the unconformity between the Lower and Middle Proterozoic. Since the overlying rocks have been removed by erosion at many of the deposits, e.g. Nabarlek, Jim Jim, White's, this observation cannot be proven.

6.2 Association of the Mineralisation with the Carbonaceous Nature of the Sediments

There is only limited information available on the more recently discovered deposits but from the evidence available there is a universal association of uranium mineralisation with carbonaceous material throughout this province.

6.3 Location of Deposits Along Fault Zones

A characteristic of the big deposits is their location along fault zones. Where faults are not immediately apparent, some alignment with major lineaments is obvious.

6.4 Shallow Nature of the Mineralisation

The mineralisation has a vertical range of rarely more than 300 feet. This is consistent with the postulated supergene origin of these deposits by leaching and transport from overlying source rocks. (Some authors quote the Pul Pul Rhyolites as sparsely mineralised with uranium.)

6.5 The Presence of Traces of Other Minerals

At the Rum Jungle deposits, copper, lead, nickel, zinc and cobalt were identified and, in fact, reached ore grade in the one deposit at White's. Gold is also a trace feature of some of the deposits.

Threadgold (1960) recognised nickel and cobalt arsenides, pyrite, gold and chalcopyrite in the South Alligator ores.

Gold, lead, zinc and copper have been identified at Jim Jim and copper is known to be present at Ranger 1.
There appears to be a certain consanguinity between the metal contents of the various deposits which suggests a common origin.

6.6 Grade of Metamorphism

The outstanding difference between the South Alligator uranium district and either the Rum Jungle or the Naborlek-Ranger-Jim Jim area is the relative low grade of metamorphism of the South Alligator district.

6.7 Age of Mineralisation

In view of the regional metamorphism in the Naborlek-Ranger-Jim Jim area and at Rum Jungle, the age is of some importance when considering the unmetamorphosed South Alligator area. Has metamorphism contributed in any way to the accumulation or concentration of larger deposits?

The Bureau seems to favour an older origin for the Nanambo Granite Gneiss.

There has been some controversy over the age of the Rum Jungle Granite Gneiss. Richards (1967) is quoted for Rb-Sr determinations that the granite gneiss is older than the sediments.

The age of the intrusive granites which accompanied geophysical development and the regional metamorphism of the Lower Proterozoic rocks has been determined at ±1800 million years.

Uranium mineralisation in the South Alligator area has been determined at 550-650 million years (a recent determination on Naborlek uranium put the age at ?? 1,000 million years).

If metamorphism of the carbonaceous sediments is much older than the uranium mineralisation, then the nature of the host rocks could have a bearing on the size of deposits.

If hydrothermal in origin, the porosity, receptiveness and chemical conditions for uranium precipitation would differ in metamorphosed schists from unmetamorphosed siltstones and cherts. Open fault structures would have been absent and uranium necessarily dispersed more widely in schistosity planes, crenulations, cavities, etc. At South Alligator by contrast, mineralisation might be restricted to open fractures and faults in relatively narrow structures.
The tendency to a preservation of a constant shallow vertical range of mineralisation is suggestive that the Jim Jim and other large deposits have formed in the same way as the small South Alligator deposits, and that metamorphic processes have not been at work.

My personal inspection of the South Alligator deposits immediately suggested that the Jim Jim deposit (for instance) is virtually a large South Alligator type deposit which has been metamorphosed.

This would require the metamorphism to be a late stage event, which is not supported by such age determinations as have been made.

Possibly the 550–660 million years age determinations for South Alligator uranium is that of a remobilised material, and the deposits are of greater antiquity. However, for a supergene origin they cannot be older than the Middle Proterozoic volcanics from which they may have been leached. This presumably would be sometime considerably later than ± 1800 million years, and weighs against a pre-metamorphosed origin for the Jim Jim uranium deposit.

6.8 General Comment

The South Alligator uranium field contains small uranium deposits, which are similar in type to the larger deposits Nabarlek-Ranger-Jim Jim area and the Rum Jungle district, except in that the host rocks - carbonaceous sediments of the Lower Proterozoic Koolpin Formation are unmetamorphosed. This does not seem to be a valid reason for excluding the possible existence of larger deposits in the area.

Exploration, particularly of the north end of the area, would complement Noranda’s exploration of its own areas to the east.

There are ample carbonaceous sediments in the area to provide the necessary reducing conditions for precipitating uranium from solution whether of supergene or hydrothermal nature.

Known fault structures may be projected northward and the unconformity at the base of the Middle Proterozoic would appear to have covered the area until recent geological times.

Uranium deposits albeit of minor scale exist, and although much detailed work on these known deposits by private companies and
government departments has failed to increase reserves, one would expect there to be other deposits. Much of the more detailed work is of a high professional standard.

The South Alligator area will undoubtedly continue to be explored for uranium, with, I believe, a reasonable chance of ultimate success.
7. GEOPHYSICS by G.N. Rodwell

7.1 Summary and Results of the Geophysical Work Completed to Date

The exploration activity in the South Alligator Valley (in particular) and the Pandanus Creek areas has closely paralleled the vagaries of the international uranium climate and fluctuated accordingly.

Ground and airborne geophysical work have been undertaken intermittently since 1955. The bulk of this work has been concentrated in the South Alligator uranium field where numerous ground scintillometer surveys have been carried out by companies both large and small and individual prospectors most of whose field data was probably not recorded.

No systematic attempt to explore the area was made until the late 1960's partly because many of the prospectors operated alone or in small groups, and also because exploration was almost entirely concentrated in or near to the favourable Lower-Upper Proterozoic unconformity which covered only a small effective area of P.A. 2225. Furthermore, the early airborne scintillometer surveys of the B.M.R. and N.A.U.C. were not sufficiently diagnostic nor the "state of the airborne art" sufficiently advanced to enable them to be successfully employed as routine reconnaissance surveys.

The airborne surveys of G.R.D. undertaken at intermittent periods between 1969 and 1971 constitute the first serious attempt to systematically explore the South Alligator and Pandanus Creek areas. Approximately 10,000 line miles have been flown by G.R.D. over these prospects using modern sophisticated radiometric sensors.

In 1970 a helicopter borne radiometric survey of short duration was undertaken in P.A. 2225 using a McPhar AV-4 spectrometer. The sources of the two significant anomalies detailed were subsequently evaluated on the ground with disappointing results.

Several ground geophysical techniques other than radiometrics have been tried over the period from 1955. The self-potential method has been particularly used because carbonaceous sediments are known to be associated with uranium occurrences in this environment. This indirect geophysical method has met with some success - including the discovery of El Sherana West - although it would be impractical to explore the multitude of S.P. anomalies arising from the ubiquitous carbonaceous material without other investigations being made.
Other indirect geophysical techniques have also been utilised. Carbonaceous material of comparatively low resistivity has been successfully delineated by the Turam fixed source E.M. method. In addition, the Sharp SE-300 EM Tilt system has been used, although data has been obtained from only 2 traverses. Two magnetometer surveys have been carried out in the South Alligator Valley.

The results and conclusions of these various surveys are described by the respective workers in the appendix to this report.

7.2 Quality of the Work Undertaken to Date

The airborne scintillometer surveys of the B.M.R. and N.A.U.C., though competently performed, are not sufficiently diagnostic to be usefully employed in the exploration for small localised uranium emitters of the type expected to occur in this environment. Examination of the N.A.U.C. flight data clearly showed the inferior quality of this data when compared with modern spectrometer records.

The G.R.D. airborne spectrometer surveys over P.As. 2212 and 2225 utilized equipment capable of discriminating, in part at least, between dissimilar gamma ray emissions. G.R.D.'s data examined to date is satisfactory except for the material of flights 12, 13 and 14 (in area 3 of P.A. 2225) which are sub-standard. G.R.D. recovered on plotted flight-lines anomalies which they considered of significance. Their interpretation of acceptable flight data is considered mediocre: most of their uranium emitters located in areas 1 and 2 are either composite emitters of little significance or are considered spurious. In addition they failed to recognise the significant uranium emitter detected on line T-44W in area 1 (P.A. 2225). Another criticism of their work is the unnecessary change in the channel scales for successive flights without adequate reason. Flight 11 (area 3, P.A. 2225) for example, although technically acceptable, utilised a uranium channel full-scale deflection of twice the obvious and optimum one - this implies carelessness. Automatic rejection of flights 12 and 13 (area 3) should have been obvious through comparison with adjacent lines of acceptable quality.
Various organisations have conducted ground geophysical surveys particularly in the South Alligator Valley, the bulk of which have been self-potential surveys which have been carried out principally by the B. M. R. This group has invariably produced competent work. A Turam survey, using a grounded primary cable, has also been undertaken, although an inductively energised primary loop system is preferred.

The conclusions of the workers who undertook these surveys are satisfactory.

The geological department of Newmont Proprietary Ltd. (partner in the Joint Venture) conducted magnetometer and E. M. test surveys in the Sterrit area and Teagues area of the South Alligator Valley to assess their applicability in this environment.

The magnetometer survey gave "promising", if inconclusive results. The E. M. system, a Sharpe SE-300 duel frequency E. M. tranceiver unsuitable for the work contemplated, nor does the paucity of field data permit a satisfactory conclusion to be drawn.

The lack of systematic approach - possibly resulting from changes in exploration management and in the prevailing geological theories - has been a stumbling block in the exploration programme, particularly of that undertaken in the South Alligator Valley.

7.3 Number and Location of Significant Radiometric Anomalies with Comments

5,575 line miles have been flown in the 1,386 sq. miles of P. A. 2225 by G. R. D. during the last two years. The areas flown, designated area 1, area 2, area 3 and the 'Middle Valley' area, are shown on plan 1. All data, except the 1,375 miles of the 'Middle Valley' area has been examined. The airbourne data perused so far consists of:

"Area 1" - flights 1 - 3 inclusive
"Area 2" - flights 1 - 8 inclusive
"Area 3" - flights 1 - 3 inclusive, 5 - 7 inclusive and 9 - 14 inclusive (Flights 4 and 8 were unproductive).

Areas 1 and 2 were flown with an Exploranium D. G. R. S. -1000 differential spectrometer. Area 3 was flown using a Nuclear Enterprises spectrometer.
All surveys were flown at a mean terrain clearance of 300 ft. and a flight line spacing of 1/5 mile. Approximately 4,200 line miles of combined magnetic and gamma ray spectrometer data was recovered in these 3 areas.

In 1969 G. R. D. undertook a combined gamma ray spectrometer and magnetometer survey over 1,335 line miles in P.A. 2212. The results of this survey have not been examined.

An additional 3,150 line miles of combined magnetometer and gamma ray spectrometer were flown in the 1,673 sq. mile P.A. 2212 (Pandanus Creek area) during the last quarter of 1970. This survey employed the same equipment and survey parameters as were used for the survey of P.A. 2225. All data from this area, which is designated Area 4, was satisfactory. This data consisted of the following:

"Area 4" - flights 1 - 4 inclusive and 6 - 17 inclusive
(Flight 5 was unproductive)

The following summarises the data for areas 1, 2, 3 and 4:

(a) The data from area 1, flights 1 to 3 was inclusive and area 2, flights 1 to 8 inclusive was satisfactory.

(b) The data for area 3, flights 1 and 2 was satisfactory, though no instrumental check was made at the end of flight 1 or prior to flight 2. The data for flights 3, 5, 6, 7, 9, 10 and 11 was satisfactory, the uranium f.s.d. of flight 11, however, was inexplicably set at double the optimum. The data obtained from flights 12, 13 and 14 of area 3 is substandard. On flight 12 and 13, the uranium trace is much too active and the calibration test is poor. The K and U channels obtained from flight 14 are unreasonably suppressed and the uranium background is far too high.

(c) All flights from area 4 (Pandanus Creek Area) are acceptable.

(d) The pre-flight and post-flight calibration checks for areas 3 and 4 do not include K or B/B data. The B/B and K data for flight lines T-9 and T-10 (area 3) is also missing. The Sleisbeek open cut (an unambiguous uranium emitter) was traversed by T-9. The B/B and K responses of this anomaly would be most useful.

The significant anomalies for each area are attached as Appendix I.
The symbols set out below have been used to classify the various anomalies:

*  Weak, dubious or possibly composite uranium emitter which nevertheless should be evaluated. Such "anomalies" if classified as "Possibly Spurious" can be rejected if there is no ground radiometric coincidence.

** Anomaly should be located and evaluated. Less dubious emitter than (*).

*** Anomaly should be investigated. Airborne anomaly is definite; the uranium emitter exists.

**** Uranium emitter stronger, or better "charactered", than (**).

***** Uranium emitter, most definitive. Strong in all channels.

Area 1

The reappraisal of G. R. D.'s airborne data has resulted in a reduction in the number of uranium emitters considered to be of significance. The sources of all G. R. D.'s "significant uranium emitters", with the exception of anomaly 110, have been examined. The results have been disappointing. Anomaly 110 has not been evaluated to date.

The breakdown of anomalies that definitely warrant follow-up is:

<table>
<thead>
<tr>
<th>Anomaly classification</th>
<th>*</th>
<th>**</th>
<th>***</th>
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<th>*****</th>
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</thead>
<tbody>
<tr>
<td>Number of anomalies</td>
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<tr>
<td>previously detected by</td>
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<tr>
<td>G. R. D. and reassessed</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>as of interest</td>
<td>11</td>
<td>5</td>
<td>5</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Number of anomalies</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>not previously detected</td>
<td>3</td>
<td>1</td>
<td>2+</td>
<td>-</td>
<td>-</td>
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</tbody>
</table>

+ (of which one is external to P. A.)
Area 2

The reappraisal of G. R. D.'s work has resulted in a reduction in the number of "significant uranium emitters".

Most of G. R. D.'s significant uranium emitters are composite emitters of little interest, or are like 216 and 221, definitely spurious. All G. R. D.'s anomalies have been evaluated with "disappointing" results.

The breakdown of anomalies that definitely warrant follow-up is:

<table>
<thead>
<tr>
<th>Anomaly classification</th>
<th>*</th>
<th>**</th>
<th>***</th>
<th>****</th>
<th>*****</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of anomalies previously detected by G. R. D. and reassessed as of interest</td>
<td>9</td>
<td>3</td>
<td>1</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>Number of anomalies not previously detected</td>
<td>6</td>
<td>-</td>
<td>-</td>
<td>-</td>
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</tbody>
</table>

Area 3

A ground follow-up programme to locate, and evaluate G. R. D.'s anomalies is under way.

The breakdown of anomalies that definitely require follow-up is:

<table>
<thead>
<tr>
<th>Anomaly classification</th>
<th>*</th>
<th>**</th>
<th>***</th>
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<th>*****</th>
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</thead>
<tbody>
<tr>
<td>Number of anomalies previously detected by G. R. D. and reassessed as of interest</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Number of anomalies not previously detected</td>
<td>8</td>
<td>-</td>
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</table>

N.B. In addition 3 "anomalies" of possible interest were obtained on the unacceptable flights 12 and 13.
Area 4

The extraordinarily strong "uranium emitter" detected on six adjacent flight lines in the Fish River Vicinity was located on the ground. This anomaly, designated the Melanie Anomaly, is considered to be due to minor surficial uranium concentrations in areas locally rich in "black soil"; it is considered of no economic significance.

Thirty additional anomalies were located by G. R. D. within the authority. Eleven of them were designated as "uranium emitters". All have been "located" on the ground with disappointing results.

A good bush track has been made to within striking distance of anomaly 30, presumably prior to drilling this anomaly, although this is probably not a "uranium emitter". There is presently insufficient evidence for the existence of a "uranium source" of the type envisaged even though the geological environment is favourable.

The breakdown of anomalies that definitely require follow-up is:

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<th>Anomaly classification</th>
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</thead>
<tbody>
<tr>
<td>Number of anomalies</td>
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<td>6</td>
<td>2</td>
<td>2</td>
<td>1</td>
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<tr>
<td>previously detected by</td>
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<td>G. R. D. and reassessed</td>
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<td>as of interest</td>
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<tr>
<td>Number of anomalies</td>
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<td>19</td>
<td>4+</td>
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<tr>
<td>not previously detected</td>
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+(of which 2 are external to P.A.)

7.4 Recommendations for Further Geophysical Work

The sources of all airborne radiometric anomalies considered to be significant should be located and thoroughly evaluated. A number of these airborne anomalies compare favourably with the original record over Jim Jim. In area 1 for example, G. R. D. anomaly 110 and the anomaly detected on T-44W are prime exploration targets.
Radiometric equipment should be capable of discriminating between the characteristic spectrograms of uranium, thorium and potassium, thus avoiding ambiguous "broad band" anomalies which may not be significant. (The "emitter-type" of anomaly 30 (area 4) could be easily resolved with such equipment.)

The magnetic data from G. R. D.'s survey in the South Alligator Valley and Pandanus Creek areas should be reduced, contoured and interpreted. The time and cost estimates for this survey are 18 man weeks and $4,000 respectively. Although these estimates depend, inter alia, upon the standard of the magnetometer records and the magnetic tie-line control.

Flight lines T-25 to T-41 inclusive (area 3) should be reflored but not until the "Middle Valley" data has been reassessed as more reflights may be required in this area. Cost of reflights should not exceed $7,000.

Additional geophysical methods should be utilized if considered of direct, or indirect use in the search for uranium, or any other potentially interesting, deposits in the area.

The surface resistivities of the area (as shown by the I.P. survey at nearby Mount Diamond) present no barrier to the use of E.M. methods, such as Turam. Such E.M. surveys are feasible in the flat areas which make up most of the prospecting authorities.

The possibility of significant base metal deposits in the area implies that it might be advisable to utilize an airborne E.M. system (but not a "V.L.F. Radio system") if a suitable aircraft is mobilised in the area.